Crossfield Products Corp.
Miracote Product Line
Explanation of Epoxy Physical Test Procedures

American Society of Testing and Materials (ASTM) Test Methods

The ASTM Standard Test Methods specify, in most cases, detailed testing procedures; however, in some cases they are relatively vague and left to interpretation regarding how to conduct the specific test. ASTM test methods do not necessarily attempt to establish the absolute physical and mechanical property values; rather, they are agreed upon procedures using techniques that are practical, equipment that is readily available and generally affordable.

As a rule of thumb, ASTM test methods Specimens for polymer systems containing 200 mesh aggregates or larger are tested with alpha designate of "C", such as ASTM C579. Polymer systems that are tested free of 200 mesh or larger aggregates are normally tested with the alpha designate of "D", such as ASTM D695.

- ASTM C = Concrete and Mortar Designations, meaning the specimen is aggregate filled.
- ASTM D = Plastic and Rubber = Designates liquids which are neat or may contain pigments and fillers, but generally speaking are free of fine and large aggregates.

Historically, the "ASTM D" series of standard tests and standard specifications covers Rubbers and Plastics, better stated today, for the Polymer Resinous Materials, including epoxies, polyurethanes, vinyl esters, polyesters, paints, varnishes, latexes, furans, etc.

ASTM D series tests are generally for "unfilled" (meaning aggregate free) resins and hardeners, which may contain fine inorganic or organic fillers, e.g., inorganics like, silica fume, talc, calcium carbonate, inorganic pigments, such as, iron oxides or organic fillers, such as, polyethylene, carbon and nylon conductive fibers and pigments containing organic colorants.

In most instances, the "ASTM D" series of test methods are not intended nor generally suitable for testing aggregate filled epoxy systems. These tests are included in the "ASTM C" series of tests that include cements, aggregate filled systems and systems with large inorganic fillers. Testing unfilled resins with "ASTM C" series is usually inappropriate.

Department of the Navy – Military Standardization Document - MIL-D-3134

MIL-D-3134 is one of the Departments of the Navy's documents for specification of deck covering materials. This document includes specified values and methods used to determine said. These tests methods are application specific and are intended as indicators of field performance.

Many of the tests require casting the material(s) on a 1/8" thick steel plate to replicate installation of a ship deck. Unlike most ASTM values, MIL-D-3134 publishes acceptable values, which are included in the specification portion of the document, therefore it is not uncommon to see references stating that the product/system meets or exceeds the test requirements.

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TESTING PROCEDURES

1. Compressive Strength

These tests indicate the yield (breaking) strength of a given specimen under a compressive load. The values are expressed in psi (pounds per square inch). The usual test is ASTM C579 Standard Test Methods for Compressive Strength of Chemical-Resistant Mortars, Grouts, Monolithic Surfacings and Polymer Concretes, Method A or B, depending on the aggregate size in the composite specimen. Method A, one inch by one inch cylinders, is used when the maximum aggregate size is #12 or less, retained on a screen that complies with U.S. Sieve Size. Method B, two-inch cubes, is employed when the aggregate exceeds #12. It is the same compressive mold as ASTM C109/C109M Standard Test Method for Tensile Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens).

If the concrete substrate compressive strength per ASTM C39/C39M Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens is between 3,500 to 5,000 psi, then individuals familiar with the concrete industry, but not with the epoxy industry may choose an epoxy with a compressive strength of 12,000 psi vs. 8,000 psi thinking that higher is better and they will have overkill. The reason to choose a high compressive strength polymer system is to obtain a high modulus material, since the modulus of polymers is significantly lower than that of concrete.

Polymer liquids, such as resins and hardeners without aggregate are usually tested per ASTM D695 Standard Test Method for Compressive Properties of Rigid Plastics is usually the test method employed for resin and hardener system without aggregate.

Normal Compressive Strength

Concrete Slab	3,000 – 3,800 psi
Polyacrylate Cement Underlayment	4,000 – 5,000 psi
1/16” to 1/8” Broadcast Quartz Flooring	8,000 – 12,000 psi
1/4” Epoxy Mortar Flooring	10,000 – 12,000 psi
Hi Impact Epoxy Mortar Flooring	14,000 – 16,000 psi
Resin/Hardener Components only	12,000 – 15,000 psi

2. Tensile Strength

These tests indicate the cohesive strength of a specimen when the material is pulled apart. The value is expressed in psi (pounds per square inch).

The polymer liquid and aggregate loaded materials are usually tested per ASTM C307 Standard Test Method for Tensile Strength of Chemical-Resistant Mortar, Grouts, and Monolithic Surfacings. The molds are the same as in ASTM C109/C109M-02 Standard Test Method for Tensile Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens). This test

determines (break) strength only; no elongation measurements are recorded, since the aggregate loading reduces tensile elongation significantly. The test indicates the strength of the mortar's matrix (epoxy binder and aggregate), particularly the bond of the binder to the aggregate particles, which is greatly influenced by the cleanliness of the aggregate itself.

Polymer liquids, such as resins and hardeners without aggregate are usually tested per ASTM D638 Standard Test Method for Tensile Properties of Plastics or ASTM D412 Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers – Tension, the physical results will be significantly different.

ASTM D638 is sometimes referred to as an epoxy "bowtie". The depth of an ASTM D638 test sample is twice the thickness or greater of ASTM D412, which is rectangular in shape. In addition, the load rate is different. When the same material is tested per these two different tensile tests, the results are remarkably different. Tensile elongation at rupture, when tested per ASTM D412, will be about twice that of the same material's tensile elongation at rupture when tested per ASTM D638.

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Normal Tensile Strength

Concrete Slab	250 - 400 psi
Polyacrylate Cement Underlayment	400 – 500 psi
Broadcast Quartz Flooring	800 – 900 psi
1/16" to 1/8" Broadcast Quartz Flooring	1,500 – 2,000 psi
1/4" Epoxy Mortar Flooring	1,400 – 1,600 psi
Hi Impact Epoxy Mortar Flooring	1,400 – 1,600 psi
Resin/Hardener Components only	1,400 – 1,600 psi

3. Flexural Strength

These tests measure the force or load required to break the material under a bending or deflection mode. The values are expressed in psi. These tests measure the system's ability to absorb lateral and flexural movement.

The polymer liquid and aggregate loaded materials are usually tested per ASTM C580 Standard Test Method for Flexural Strength and Modulus of Elasticity of Chemical-Resistant Mortars, Grouts, Monolithic Surfacings, and Polymer Concretes.

Polymer liquids, such as resins and hardeners are tested per ASTM D790 Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.

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4. Indentation

This test measures the indentability of the flooring system under a dead load of 2,000 psi for 30 minutes.

Material is applied to a steel plate and a steel indenter (steel cylinder with a one sq. inch footprint) is applied under a 2,000 lb. load for 30 minutes at a ambient temperature of 72^0F. The indentation is measured and expressed in inches or as a percentage of the thickness of the flooring. This test is conducted in accordance with military specification Mil-D-3134 Para 4.7.4.

Normal psi of common objects

Spike heels worn by 135-lb. woman	3,000 psi
Desk with four legs	150 psi
File cabinet	10 psi
Forklift (without cargo)	120 psi

5. Weight

This test simply indicates the average dry weight of the flooring system expressed in psi when the material is installed at an average thickness. Although simple, this is an important value for engineers and specifiers when calculating the required structural components required to support the weight of the structure. Any accurate method for weighing the flooring components is acceptable for this determination.

6. Moisture Absorption

This test indicates the tendency of the material to absorb and retain water. Moisture can be both absorbed and adsorbed. Absorption is the moisture gain in the cured liquids or aggregates of the system and held as residual moisture. Adsorption is the surface retention of moisture that is taken in by the matrix and held by the composite system. The values are expressed as a percentage of the weight gain.

Materials are cast into 2” X 2” X 1/4” specimens. The specimens are weighted, immersed and then weighed again. This test is run in accordance with Military Specification Mil-D-3134 Para 4.7.8.

A low value (less than 1%) would indicate most water would run off and that which was absorbed would evaporate out and dry quickly. A high value would indicate the system would retain moisture and dry slowly.

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7. Resistance to Impact

This test measures the ability of the surfacing to resist cracking, chipping, spalling or breaking bond when subject to a dynamic load. This is a severe test that requires the material being applied to a steel substrate, because the force of impact on a concrete substrate would normally fail during testing and render the test results invalid. The value is expressed in/in of depression or compression.

Materials are applied to a steel plate and the specimen is subject to the dynamic load of a 2 lb. steel ball dropped twice from a distance of 8 ft. The depth of depression is measured, and the sample is examined for any sign of chipping, cracking or delamination, conditions are noted. This test is conducted in accordance with military specification Mil-D-3134 Para 4.7.3.

8. Oil Absorption

This test is similar to the water abortion test and indicates how much oil can be taken in by the system. Oil is much more viscous than water and can cause swelling of the system components which will lead to premature deterioration of the surfacing system. This test is critical for industrial type flooring systems that are exposed to petroleum products.

Materials are cast into 2" X 2" X 1/4" specimens. The specimens are weighed, immersed in Medium No. 3 oil as listed in Fed–Std-601 and then weighed and measured. This test is run in accordance with Military Specification Mil-D-3134 Para 4.7.12. Values should not exceed 2%.

9. Coefficient of Thermal Expansion

This measures the dimension change of the mass of the flooring system when exposed to changes in temperatures. All materials used in flooring systems expand as the temperatures rise. The important element is that the thermal expansion of the flooring system is comparable with that of the substrate. The more severe and extreme the change in temperature condition, the more critical the Coefficient of Thermal Expansion is similar.

The value is expressed as inches changed per inch of length per degree Fahrenheit ($in/^0F$). Results of this test are in such small figures that it is expressed as a number times a negative power of ten i.e. 2.5×10^{-5} $in/^0F$. Materials are tested in accordance with ASTM C531 Standard Test for Linear Shrinkage and Coefficient of Thermal Expansion of Chemical-Resistant Mortars, Grouts, Monolithic Surfacings, and Polymer Concretes.

10. Resistance to Elevated Temperature

This test indicates the effect of elevated temperature on the flooring. The specimen is subject to elevated temperatures of 100^0F, 120^0F, 140^0F, and 160^0F. Material is applied to a steel plate and a steel indenter (steel cylinder with a one square inch footprint) is applied under a 2,000 lb. load for 30 minutes at varying temperatures. The indentation is measured and expressed in

inches or as a percentage of the thickness of the flooring. This test is conducted in accordance with military specification Mil-D-3134 Para 4.7.4.

For resistance to higher temperatures specimens are placed in boiling water for extended periods of time and examined for signs of deterioration or softening.

11. Abrasion Resistance

Abrasion resistance is the measurement of wear and the ability of the flooring system to resist wearing. This test is often misunderstood because of the numerous variations available in conducting the test. The two most common test methods are as follows:

The Tabor Abrader is the most common method for evaluating abrasion resistance. Materials are usually tested in accordance with ASTM D4060 Standard Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser. A specimen is cast and subject to 1000 cycles of abrasion by an abrasive wheel. This wheel is changeable to different grit or grade of abrasive. The most common grit wheel is a C-17. The C-17 wheel is generally considered to replicate the wear of normal foot traffic. A 1,000-gram load is applied to two C-17 wheels and the specimen is subject to 1000 cycles. The value is expressed in grams or milligrams of weight loss by abrasion.

The second method measures wear by loss when subject to 80 grit aluminum oxide sandpaper. The value is expressed in inches of loss i.e., 0.096” Loss. This test is conducted in accordance with military specification Mil-D-3134 Para 4.7.10.

12. Slip Resistance

This test measures the relative amount of force it takes for a leather or rubber to begin sliding (Static Friction) or to continue sliding (Sliding Friction) under dry, wet (with water) and oily surface conditions. The values are expressed in pounds. Materials are tested in accordance with military specification Mil-D-3134 Para 4.7.6.

The higher the number, the greater the resistance to slip. Conversely, the lower the number the more slip. Surface texture and on-site cleaning procedures affect results.

Skid Resistant Systems			
STATIC FRICTION		LEATHER	RUBBER
	Dry	0.51	1.03
	Wet	1.01	1.08
	Oil		0.43
SLIDING FRICTION		LEATHER	RUBBER
	Dry	0.73	1.09
	Wet	1.01	1.08
	Oil		0.43

The Static Friction Test measures the amount of "pull" that it takes for a leather heel or a rubber heel to start slipping. The Sliding Friction Tests measures continued slip. Both tests are under dry, wet (water) and oily conditions, and are expressed in pounds. The values are only relative for comparative (product A to product B). For test evaluation purposes, the test readings are classified as:

0.6 or Greater	Relatively Non-Slippery
0.5 to 0.6	Generally Acceptable
0.49 or less	Relatively Slippery

Test is run in accordance with MIL D 3134, Paragraph 4.7.6, with the Horizontal Pull Slipmeter, manufactured by: Olson Medical Products, Inc., Ashland, MA

Americans with Disabilities Act

The minimum slip resistance required by The Americans with Disabilities Act is 0.60. All products manufactured by Crossfield Products exceed this minimum requirement.

Thin-Set Epoxy Terrazzo Floors

Epoxy Terrazzo (by inference other relatively smooth epoxy flooring systems) is U/L listed as "Slip Resistant", per the National Terrazzo and Mosaic Association.

13. Elongation

This test only applies to elastomeric materials that are designed to elongate or stretch over movement in the substrate. This test measures the elasticity of the material before the breaking point. The value is expressed as a percent of the material thickness before the system ruptures.

Most elastomeric materials elongate between 200 – 550 %.

14. Moisture Vapor Permeability

This is used to determine the rate at which moisture vapor will pass through the flooring or coating. The test specimen is mounted over a chamber with 100% humidity inside chamber and a desiccated (completely dry 0% humidity) atmosphere above the test specimen. This creates an atmosphere condition whereas the high humidity area will want to equalize with the area of low humidity. This equalization is conducted by osmosis transfer, which passes through the test specimen.

The perm rate is the value expressed in milligrams of water that permeate 1 sq. cm of film of 1mm thickness each 24 hour period after a constant rate has been obtained under the test conditions.

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Materials are tested in accordance with ASTM D1653 Standard Test Methods for Water Vapor Transmission of Organic Coating Films.

15. Adhesive Strength

This test measures the bond strength of the flooring or coating to the substrate. There are two primary test methods. The first method is for adhesion to concrete substrates. The material is applied to a concrete substrate and a dolly is attached to the flooring and the material is pulled off substrate. The force required to pull the flooring off the concrete substrate is expressed in psi. The tensile strength of the concrete substrate should fail before the bond of the flooring or coating. This is usually about 350 – 400 psi.

Materials are tested in accordance with ACI 503 (American Concrete Institute test method 503R) and ASTM D4541 Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers.

The second test method involves bonding the material to a steel plate and shearing the material off in a lateral movement. This test is conducted in accordance with military specification Mil-D-3134 Para 4.7.14.

16. Accelerated Light & Immersion Resistance

This test is a synthetic acceleration test designed to simulate actual conditions of exposure to ultraviolet light and saltwater. This test is design to determine the suitability of a material for exterior exposure. The test is run for 72 hours with 36 cycles that consist of 4 minutes of immersion in a 10% solution of sodium chloride followed by 1 hr. and 56 minutes exposure to carbon arc light. The specimen is examined for color stability, cracking, checking, crazing or any other signs of deterioration.

Materials are tested in accordance with military specification Mil-D-3134 Para 4.7.15.

17. Accelerated Light & Weather Aging Resistance

This test is similar to the Accelerated Light & Immersion Resistance Test, except that a water spray is used instead of the sodium chloride immersion. The test is conducted over a 200-hour period. The specimen is examined for color stability, cracking, checking, crazing or any other signs of deterioration.

Materials are test in accordance with military specification Mil-D-3134 Para 4.7.16.

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18. Thermal Conductivity

This test is conducted by applying the material between two steel plates; one of which is hot and the other is cool. By means of thermocouples, any transmission of heat can then be determined. This heat loss is than expressed in BTU (British Thermal Units).

"K" value is the expression of thermal conductivity. This is the amount of heat (expressed in BTU's) that is transferred in one hour, through one sq. of a homogenous singular material, one inch thick for each one degree Fahrenheit of temperature difference between the two surfaces of the material

Materials are tested in accordance with ASTM C177 Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.